SECTOR TEST: OVERVIEW, MOTIVATION AND SCHEDULING

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Abstract

An overview of, and the motivation for the sector test, are recalled. The scheduling of the preparatory steps, the test itself and recovery from the test are presented. This is presented together with the potential impact and interaction with hardware commissioning and ongoing installation.

INTRODUCTION

An LHC sector test was approved in 2003. This test plans to inject beam down TI8, into the LHC at the injection point right of IP8, traverse IR8 and LHCb, through sector 8-7 to a temporary dump located near the position of Q6 right of point 7. The motivations for performing this test were originally outlined at Chamonix 2003 [1,2]. However, there are many consequences and the potential impact was also examined [3].

The test will involve the final part of TI8 and 3.3 km of the LHC including one experiment insertion and a full arc. As such it may be regarded as very representative of the challenges we will face in commissioning the whole machine.

It is clear that the test is inconvenient, coming as it does, during installation and hardware commissioning, but, it will be argued, it is justified.

Beam

The aim is to use pilot beam for the most part i.e. a single bunch with an intensity of 5 - 10 x 10^9 protons. The clear aim to minimise losses, use beam sparingly and only when we know where it's going.

The planned total intensity will be at maximum 4 x 10^{13} protons delivered over 2 weeks. This is comparable with one nominal intensity LHC extraction from the SPS.

MOTIVATION

A test with beam of part of an accelerator during the installation process is standard and the motivations in the case of the LHC have been well debated [1,2,3]. Such a test allows one to:

Verify system wide integration: full-blown system wide integration tests necessary for beam go one step beyond hardware commissioning. It allows one to field test beam related equipment such as: power converters, kickers, septa, dumps, pickups, synchronisation, timing, and to get them all working together. It stress tests the controls infrastructure and will fully validate integration and highlight oversights, and force the debugging of problems. There will be problems and the lessons learnt will undoubtedly speed full commissioning.

Check that the installed equipment works with beam, and that there are no problems with ongoing installation. Beam will confirm that the aperture in the cold machine is free and has the expected size. The beam samples all electromagnetic fields in the vacuum pipe and will allow polarity checks of the corrector elements and the beam position monitors, measurements of field errors, and determination of any large offsets between beam and magnet. Linear optics checks are also possible.

It will be the first exposure to beam of much of the hardware and will, potentially, allow verification of assumed quench limits and spatial resolution of beam losses.

Pre-commission essential acquisition and correction procedures. First tests of important beam diagnostic system will be possible. The beam provides the only way to verify the proper functioning of the diagnostics: timing, BPM resolution, BPM cabling, BPM offsets, BLM resolution. It will allow tests of the control and correction systems (including correctors, cabling, the control system, software, procedures etc.).

Last but not least it will provide an extremely **high profile milestone** forcing the preparedness of all components. These would include controls, timing, transfer from the injectors, instrumentation, interlocks, access, radiation protection etc.

These systems are absolutely critical for the effective exploitation of the machine. They must be ready and tested when we come to commission the whole machine. The test can potentially highlight oversights, misconceptions and shortcomings.

Operationally the exercise would be extremely valuable and it can be argued that the time and effort spent on the test will be more than compensated by a more efficient start-up of the completed machine.

Commissioning of the first sector will have to be done sooner or later. We will have to wrestle with the problems that will be encountered during this phase. Discovering the problems during a sector test will give us several months at least to resolve any problems, perform a critical analysis of the performance of the systems involved and implement improvements. Operationally, any time spent in 2006 on an injection test will be paid back during the first year's commissioning, enabling us to deliver physics faster.

A successful test would also validate the project to the wider world.

De-motivation

It might be argued that if any serious problems are uncovered then it would be too late to change anything. Related is the question: "What do you if you can't get beam around after two weeks?" Clearly the sooner any problems, serious or otherwise, are revealed the better.

Anything uncovered during the test would give us at least some lead time to find a possible resolution.

It is also argued that many things will change between the test and full commissioning and we will have to re-do the exercise anyway. The counter-argument is that most of the accelerator systems will necessarily be in the final configuration for the test. Every attempt should be made to avoid temporary solutions for the test.

We are going to be busy enough anyway installing and commissioning other sectors and the test will provide a distraction and a draw on valuable resources. It is undoubtedly true that the test will place demands on the teams involved and draw resources from the installation and hardware commissioning. The impact and potential cost of the test is discussed below.

IMPACT

Installation

The test will necessitate the closing of sector 7-8, part of 6-7 and part of 8-1. Thus transport of magnets through the sector 7-8, and interconnect work in the closed part of 6-7 will not be possible for the duration of the test.

- No transport through 7-8 during preparation (7 days), tests with beam (14 days) and recovery (7 days).
- No access to part of 6-7 during test (17 days).
- No access to part of 8-1 during test (17 days).

Details of how these constraints can be accommodated into the overall planning are given elsewhere in these proceedings [4]. One should note that work should have finished in sector 8-1; that work can continue in the unclosed part of 6-7; and that it is possible for magnet transport to continue albeit not through sector 7-8.

Hardware Commissioning

The test sets a hard deadline for the hardware commissioning of sector 7-8 and the requisite part of 8-1.

Given that the test is to be performed at 450 GeV, the possibility that the circuits involved (particularly the main bends and quadrupoles) be commissioned to less than nominal current is a possibility. Hardware safety must, of course, be guaranteed. A full list of required circuits and expected operational range may be found at [5].

Partial hardware commissioning would, however, mean the hardware commissioning team re-visiting sector 7-8 after the test, with inevitable overheads. For a further discussion of the hardware commissioning issues see [6].

Radiation Protection

Remenant radiation after the test will potentially force parts of 7-8 and 8-1 to be declared a Supervised Radiation Areas with knock-on effects for magnet transport and subsequent installation [7,8].

Resources

The test will clearly use resources: both manpower in the preparation, execution and recovery, material costs for items, which are not part of the final LHC configuration, plus exploitation expenses.

Clearly the test places demands on what is to be installed and operational. There are also some small constraints on what is not to be installed in the area to the right of IP7.

Cost

Initial estimates made in 2003 [3] included the need to re-cool and re-hardware commission sector 7-8. This will be unnecessary given the present schedule. However, running the PS/SPS complex solely for the test during part of November/December suffers from the high cost of electricity at this time of the year.

As before the capital costs are relatively small, given the closeness of the machine to the final configuration.

SCHEDULE

An overview of the near test schedule is shown in table 1. The dates shown reflect the schedule as of February 2006. If the dates for the test were to change the essential breakdown would stay the same. A detailed breakdown is available at [5].

Task	Date	Comment
IR7 Vacuum & BDI	1-7/11	**No interference**
Machine Checkout	13-24/11	**Control from CCC**
Install Dump IR7	15-17/11	**7-8 blocked**
Access system	20-23/11	**Tests**
Close sector	23/11	**Qualification**
Beam to TI TED	24/11	**Point 8 closed**
Sector test with beam	27/11 – 10/12	**6-7,7-8, 8-1 closed**
Radiation survey	11/12	
Access gates out	12-13/11	**6-7, 8-1 free**
Dump out	18-19/11	**7-8 free**

Table 1: Overview of near test schedule

CONCLUSIONS

The LHC sector test is an important milestone. It provides an opportunity to thoroughly test full integration of a wide variety of accelerator systems, all of which will be needed for machine commissioning. It also allows important beam based checks of the ongoing installation.

The time spent will be recuperated during eventual commissioning, and perhaps, more profoundly it will allow more effective and rapid commissioning, having given time for problem resolution and improvements.

Although it does impact on installation, its effects are well constrained and manageable. Careful planning is required to fully anticipate the requirements and effects of the test in order to minimise the disruption it will cause to other ongoing activities.

REFERENCES

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